Portuguese Living Standards 1720-1980 – Heights, Income and Human Capital

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Abstract

We provide new data on the 18th century and trace a long-run trend of Portuguese living standards from the 1720s on. We find that during the early 19th century they still were on a similar level as other European countries. Around mid-century, the record of anthropometric values of many European countries increased strongly but Portugal diverged. We find that retarded human capital formation, among other determinants, played a crucial role in the divergence of Portuguese living standards from the European core at the end of the 19th century.

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Introduction

Portugal has an impressive early history, providing, for example, famous seafarers and discoverers, that changed Europe’s position in the World. During the Renaissance, Portugal’s scientists were at the cutting edge of maritime science and navigation. Their knowledge helped to revolutionize the understanding of the then existing world, with the expeditions alongside the African west coast or in Latin America or the discovery of the sea route to India by Vasco da Gama. However, more recently, the Portuguese have considered themselves a somewhat backward economy in comparison to the rest of Europe. In anthropometric terms, this may well be true, if we look at Portuguese height records at the end of the twentieth century. They turn out to be the shortest of all Europeans (Sobral 1990; for the European comparison see Reis 2002/03, Reis 2009, Baten 2009; for earlier Portuguese data see Padez and Johnston 1999, Padez 2007, www.undp.org). When and why did the Portuguese become so short?

The aim of this article is twofold. First, we provide new empirical data on early modern living standards. By reconstructing Portuguese height development over almost three centuries, from the 1720s to the late 20th century, we actually find the Portuguese in the early 18th century still on a similar height level as a sample of European countries. In a second step, we turn to the causes of this evolution and find that retarded real wage convergence and human capital formation were the most important factors that hindered a better performance of Portuguese biological standard of living.

To answer these questions, we mobilize a number of fresh resources for Portugal and compare them to evidence from Southern, Central and Eastern Europe. The main new data set covers the evolution of heights between the birth decades of the 1720s to the 1830s. So, for the first time, a documentation of 18th century Portuguese heights is provided in this study. Additionally, we extend existing data sets (Reis 2002/03, Reis 2009) that include Portuguese
heights until 1910 with new evidence from the north and the hinterland, to achieve a better geographical coverage of Portugal. During the period 1910-1980 heights have been documented by Sobral (1990) and Padez (2007). We compare Portuguese heights to a sample of European countries to determine the period of divergence in biological living standards. It turns out that the Portuguese suffered a severe stagnation of living standards after 1840, whereas other European regions experienced sustained upward trends. From the 1870s on, the Portuguese became the shortest in Europe.

We also provide in this study a significant extension of the series for Portuguese real wages for the period 1720-1850, where data was not available before. Furthermore, we compile new evidence on relative prices for a sample of European countries. Also, new estimates of Portuguese numeracy during the early 18th century, based on inquisition records are provided, as well as fresh data on 19th century infant mortality. Hence, a long-run source base for Portugal is created here for the first time which allows understanding the evolution of Portuguese living standards in a broader perspective.

We first introduce the height data, and then estimate a height trend for the period 1720-1910. We compare it to a sample of European countries in order to analyze whether Portuguese heights were always shorter than the rest of Europe. Doing this comparison, we also contribute to the understanding of welfare development in all of Europe. In the next step, we scrutinize possible determinants and test our hypothesis with an unbalanced panel regression. We end with a conclusion.

Data

Our height data set covers almost three centuries of Portuguese height development, if we include the 20th century data which has been studied by other authors (Sobral 1990, Padez 2007). This is the longest time span analyzed so far in one single article on archival height records (only studies on archaeological height evidence span longer periods). This is possible,
because the Portuguese archives contain data of high quality already for the 18th century. We use military records from various archives in Portugal (Table 1). In the *Arquivo Histórico Militar (Lisbon)*, we collected large samples for the recruitment years of 1763, 1791, and the 1820s-1840s, and a few smaller ones for the years in between (Table 2). The concentration on the recruitment decades 1760s, 1790s and 1820s allows us to cover all birth decades since the 1720s with sufficient numbers of observations, even if the 1720s birth cohort has only a small number of cases. After the 1820s, height information is more abundant and we collected a large sample for each measurement period. This is true especially after the 1850s. The data set after 1857 has already been documented in Reis (2002/03, 2009). It was extended by 3,889 observations from the north of Portugal (*Viana do Castelo, Braga* and *Porto*) from the *Arquivo Geral do Exército (Lisbon)*. We added further observations from the district archives of *Evora, Faro* and *Porto*.

Geographically, the data set was standardized to the Portuguese districts as they exist today. The recruits born in the 18th and early 19th century came from different Portuguese regions, whereas the post-1857 evidence has a slight concentration on Lisbon heights. Nevertheless, even for this period sufficient observations are included from other parts of the country. Hence, good geographical coverage allows controlling for geographical composition when we estimate the time trends for the whole period under study.

The sources contain information about professional status of the recruits. Although many of them might not yet have reached their final professional stage, this provides some evidence about the social and economic composition of the army and the socioeconomic background of the recruits in general. In the 18th and 19th century the father’s profession often determined the occupational choice of the offspring, as mobility between social classes was not that strong. The share of recruits who reported any occupation rose from the birth decades of the 1720s-1750s to 1760s-1790s from 63 to 80 percent, and then fell again (70% for 1800s-
the share of skilled and professional occupations among those who reported occupations (as opposed to unskilled and semiskilled occupations). We use for this the Armstrong scheme of six occupational status groups, which was designed to classify occupations of nineteenth century censuses according to skill level (Armstrong 1972). The share of skilled occupations was fairly constant over time (Figure 1). Relatively few reported any occupations in the earliest cohorts which required some skills, but between the 1750s and 1860s, the share of skilled occupations was mostly between 31 and 37 percent. Later, the share of skilled recruits rose, probably reflecting a similar increase in Portuguese society during the late 19th and early 20th century. This last part of the sample is representative for the sampled districts by definition, as the sources are based on general conscription, which was introduced in 1857.

We exclude extreme heights (below 120 and above 200 cm) and analyze only recruits aged 19 to 50, to avoid individuals who are still growing or already shrinking. We include dummy variables for ages 19-22, to control for late growth. Our data also provided some challenges, to which we turn now in detail.

**Minimum height requirements (MHR)**

Prior to the introduction of universal military service in 1857, the only men who had their height measured were those considered capable and who actually served in the military. Hence, the data is truncated below the minimum height requirement. How does this affect the selectivity of our data? According to Dores Costa (1995), the reluctance to serve in the army was very high among the Portuguese, even compared to other countries. Formal and informal protection networks existed that enabled the upper social strata and also some ordinary people to avoid military duty and hence to escape measurement. Therefore, those who actually joined the army were certainly not a positively selected sample of the underlying population, in spite of the somewhat high minimum height requirements applying in the early eighteenth century.
The histograms in figures 2 - 4 show the truncation points of the height distributions in the pre-1857 data. In 1763 and 1774, the distribution falls short below 62 inches (Figure 2). In 1776 to 1802, the data is truncated at 60 inches (*polegadas*) (Figure 3). On the right side of the distribution, the effect of a grenadier distribution (N=169) becomes visible, as they were supposed to be taller. Therefore, we control for grenadiers in our regressions. In the recruitment period of the 1820s, we observe a steep jump from 56 to 57 inches, and another one between 57 and 58 inches (Figure 4). Hence, we conclude that over time three different MHRs applied: between 1763 and 1775, 62 Polegadas; between 1776 and 1807 60 Polegadas, and after 1820, 57 Polegadas. The literature confirms all three minimum height requirements. The original regulation of Count Lippe in 1762 has been preserved (Lippe 1762), stating 62 polegadas as minimum height requirement. In 1776, the Marquês de Pombal decreed a reform and extension of the army. He wanted to provide a broader basis of recruits (Selvagem 1931). Selvagem (1931) does not refer to minimum height requirements but we believe that the measure, by which the Marquês increased the army, was actually a lowered MHR. A source published a few years later (Da Silva Lopes, 1819), also confirms the MHR of 60 polegadas by stating that for years it had been the custom in the infantry to admit men of 5 feet and 4 polegadas, i.e. 60 inches as a minimum. The next documented MHR was approved by the parliament in 1823 and was 57.5 polegadas¹, which also matches our histograms. In 1857, general conscription was introduced, with a MHR now of 155 centimetres (56.8 polegadas) and after 1887 of 154 centimetres (56.6 polegadas). Almost all recruits were measured and examined, and we can include the height even of those, who were not accepted for military service for height or for other reasons.

¹ See Diario da Camara dos Srs. Deputados da nação Portuguesa

Below, we control for the MHRs by using a truncated maximum likelihood method with varying lower limits for the recruitment regimes before 1857. As the data does not suffer from truncation thereafter, we use simple OLS regression techniques for the following period.

**In which units was height measured?**

A second problem connected with the measurement of height for military purposes prior to the middle of the nineteenth century has to do with the reform of the metric system and the consequent need for us to convert the Portuguese feet and inches into the metric system. This was introduced in Portugal in 1852 and began to be generally enforced 10 years later, except for the army which introduced it immediately. The official Portuguese pre-metric inch (polegada) was 2.75 cm, a relatively large one by international standards (see for example Da Silva Lopes 1849: 80). We estimated height trends by recruitment period and while we can confirm the application of the 2.75 inch from the 1820s recruitment period on, we have to reject this assumption for the 18th century (Figure 5). If the official Portuguese measure is applied, the height levels for the recruitment system 1763-1802 are almost 10 cm higher for soldiers born in the 1780s, compared to soldiers of the same birth decade measured after 1820. This is implausible. Clearly, the recruitment systems were different and might have led to a stronger selectivity in the eighteenth century, but this selectivity would have been the other way round: we would expect smaller mean heights due to negative selection of the 1780s recruits (see Dores Costa 1995). Moreover, while we find completely different height levels for the same birth decade, the recruits were of roughly similar skill level and regional composition. This leads us to the conclusion that a different linear measure was used for the early recruitment system. There are many examples from other countries, in which the official measure was not used, but a different measure adopted from other countries instead. After considering the historical context, we compared various possible measures with the level of

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2 Andalucia, for example, used a French measure during the early 19th century (Hueso 2006). In Brazilian prisons, Frank (2006) found a yardstick that yielded 2.73cm instead of the official 2.75cm.
the 1780s and found that if the Rhenish foot had been used in the early recruitment system, the height levels of the 1780s are consistent with the data from the early and the post 1820 recruitment system. Other measures result in a positive or negative divergence. Is it plausible, that a Rhenish (=Dutch, = Prussian) measure was used? The Netherlands were an important trading partner, and the measure was exported to many countries which officially had also own measures. Perhaps even more importantly, the restructuring of the Portuguese army in the 1760s, under Count Schaumburg-Lippe, a North-German, bureaucratic and measurement-enthusiastic spirit, could have inspired the adoption of the Rhenish measure.  

This was kept for a few decades, until the national standardization of measures during the early 19th century implied a switch to the official Portuguese measure. We find some evidence in the literature, that the Count of Schaumburg-Lippe had, in fact, manipulated the measure. In 1763, we find an instruction on the minimum height requirement applied during that period, which refers to 62 “Polegadas alargadas”, which means extended, broadened or widened inches. As applying an inch that equals even more than 2.75 cm would not be plausible, in this case, we conclude, that the “extension” referred to the increased number of inches for a given stature. In other words, this measure yielded more inches than in case of the normal inch applied was therefore ‘alargada’. Hence, we conclude that the Rhenish measure was used and apply this in our analysis.

**Portuguese versus European Biological Living Standards 1720 – 1980**

We estimated the Portuguese height trend with control variables for army category, birth decade, age, regional composition and changing minimum height requirement with an adjustment for adult height levels (Table 3). To compare the Portuguese development of living standards to Europe, we use a sample of European countries that contains Austria, England, France, Germany, Hungary, Italy, Ireland, Russia, Spain and Sweden. We separated

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3 For an account of these reforms, which were sweeping, see Barata and Teixeira (2003-2004).
these countries into three groups, according to their geographical situation, and constructed southern, central and east European groups as well. Southern Europe contains Italy and Spain, central Europe includes both the centre and the northwest countries: Austria, England, France, Germany, Ireland and Sweden. Eastern Europe is represented by Russian, Polish and Hungarian heights (Figure 6).

The Portuguese of the early modern period were actually taller than the French, the Russians or the Saxons (Cinnirella and Komlos 2007). Figure 6 shows that during the early 18th century, Portuguese heights were on a similar level as the European average, at a time of relatively low dispersion among European regions. Until the 1760s, a solid increase in heights is observable, a period in which the Minas Gerais gold and diamond rush and the transatlantic slave trade and a growing plantation economy made Brazil a lucrative overseas territory for Portugal. In 1760, the Portuguese were between one and two cm shorter than the central European sample, yet the development of the trends proceeded quite closely and in a parallel fashion. From the 1770s on, heights decrease until the birth cohort of the 1790s, where biological living standards reached their lowest point of the whole period under study. The low point in the 1790s birth cohort is also evident in the Eastern and Central European trends. At the beginning of the nineteenth century, biological living standards in Portugal started to improve in spite of difficult political circumstances and a degree of economic dislocation during the Napoleonic wars and their aftermath. Heights reached a peak in the 1820 birth decade, which was even slightly above the eighteenth century maximum, which matches the fact that harvests were quite good during the 1820s. Portuguese living standards overtook the south and east of Europe and were on a similar level with Central Europeans. However, the next two decades, saw the beginning of a long term divergence between Portuguese and central European heights. It was heralded by the strong dip of the “Hungry Forties” in Portugal. Declining heights were also visible in other Southern European countries because of
difficult climate conditions and bad harvests all over Europe during this period. We find an unusually large part of the conscripts born during this decade with heights below 140 cm – a clear sign of severe stunting. In contrast to the rest of Europe, this difficult period was followed by another dramatic decade in Portugal, characterized by falling real wages caused by a succession of agricultural disasters, which lasted until the 1860s and was not followed by the steady long term upward movement which was visible elsewhere in Europe. Portuguese heights stagnated for the remainder of the century. In the 1890s, Portugal even lags behind the development of the European south (Spain and Italy); the effect was a gap of about 5 cm relative to the European mean in the 1910 birth cohort.

Only from the 1910s on did a sustained process of slow height increase begin to emerge. It was very slow even until the 1950s, when anthropometric values finally exceeded the peak of 1820s. From this point on, heights grew substantially until the end of the period under consideration, a fact attributed by Padez (2007) to favourable socio-economic changes in Portugal. In particular, nutrition and the Portuguese health system improved between the 1940s and the 1970s. This was reflected also in vital statistics, with a strong increase in life expectancy at birth, which rose from just over 50 years, to 71, three decades later.4

Meanwhile, the same was happening also in the rest of Europe and at similar or even larger rates of change. As a result, despite this more vigorous performance, convergence in living standards failed to materialize and in 1980, Portuguese were more than seven centimetres shorter than people living in the core-European countries, which left Portugal as striking outlier in the economic region to which it belongs. Even during the Golden Age of the 1950s and 1970s, when it had one of the most rapid rates of economic growth in Europe, it was unable to close this gap, not even to other Southern European countries. So what was the exact time point, when the Portuguese became the shortest in Europe? We find that it was in

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4 In 1902, life expectation at birth in Portugal was 44 years. See Costa Leite (2005).
the 1890s that even Spanish and Italian heights grew taller than the Portuguese. The crucial question thus arising is: why was Portugal’s development persistently retarded in comparison to the rest of Europe after mid-19th century? In the next section, we mobilize a number of explanatory variables, to provide an answer to this puzzle. We concentrate on the period, in which the deviation of Portuguese heights from the European standard occurred, the period until 1910, trying to explain, why this gap opened up.

**Determinants of the biological standard of living in Portugal**

Stature is a function of nutritional quantity and quality, hygienic conditions and medical care during the early years in life. These components in turn are determined by socio-economic factors like income, inequality in a society, public health, relative prices and other factors (Steckel 1995). Hence, it is the behaviour and income of the family or the parents on the one hand, and prices for food, medical care and shelter on the other hand that determine the outcome of stature. Aside from the economic variables like income and prices, basic human capital formation has an important impact on the biological standard of living directly via the behaviour of the parents. Below, we also scrutinize the availability of high quality protein, a possible effect of urbanization and selective migration.

**Real Wages**

As the quantity and the quality of food, shelter and other goods that influence heights is determined by purchasing power, we first investigated the evolution of real wages for our panel. This indicator is strongly correlated with GDP, but is capable of revealing distributional, allocative and environmental dimensions of welfare which are dismissed by a more aggregate indicator. A series for Lisbon real wages (skilled and unskilled) during the 1800-1900 period was established some time ago using data drawn from the Royal Household accounts and from a charitable Lisbon institution (Reis 2005b). A similar study using these and other institutional sources is currently under way and allows the extension of the earlier
series back to the early 18th century. We follow Allen’s (2001) procedure, which uses the “welfare ratio” concept. He calculated how far the yearly income of a male adult labourer (who worked 250 days in a year) would go towards purchasing the number of consumption baskets deemed sufficient to maintain a normal sized family (two adults and two children). The basket is derived for Strasbourg in the middle of the 18th century, with appropriate adjustments for variations in diets and availability of basic goods. For the first time, a real wage series for Lisbon for the 18th century is provided by this project (Figure 7). We compare these real wages of unskilled workers to a set of European countries, which we already used for the height comparison (Figure 8). The Lisbon trend declined between the early 18th century and the period around 1800, then recovered until the 1820s, when Portugal reached its maximum height level before the 20th century. Afterwards, real wages fell, reaching a low point in the 1850s. The development until 1900 was disappointing. During the 20th century, sustained real wage growth only emerged from the 1950s on (Williamson 1995). In European comparison, until 1740, Lisbon real wages compare well to other European regions (Figure 8). After the early 19th century, east and central European wages take off, while Lisbon wages stagnate (and even decrease in 1840-1860). Wages in Milan and Madrid are much smaller than in Lisbon until the 1800s, but afterwards, they have a somewhat higher level. Previous studies have detected important deviations of the income – height relationship (i.e. the early industrial growth puzzle, or the antebellum puzzle, e.g. Komlos 1998 or Komlos 1996). But in our European panel, both indicators evolve quite similarly. We consider real wages to be a potentially important determinant of heights and will put this hypothesis to test in our regression analysis.

5 Except that here, the European east is represented by the cities of Krakow and Warsaw for lack of other Russian real wage data (Allen 2001), but Warsaw is still part of the Russian Empire during the respective period.
6 An estimate by Valerio (2008) for the first half of the 19th century suggests that Portuguese real GDP per capita fell by about 30% over the period 1800-1850.
Human Capital

Tortella (1994) and others have stressed the role of underinvestment in human capital as an important factor of long-term economic development in the Latin economies, including in Portugal in particular. In fact, Portugal performs poorly in terms of primary school enrolment and literacy rates. In 1890, Portuguese literacy rates and primary school enrolment rates were among the lowest in Europe (ibid). Around 1800, less than 20 percent of rural population was able to sign their name (Reis 2005a). For the late nineteenth century, we find qualitative sources complaining about the low standard of human capital in Portugal, jeopardizing absorption of foreign technology, because the workforce was badly educated and not capable of handling the imported machines and equipment properly (Reis 2004). Pedro Lains (2003, 2007), an expert on Portuguese economic history, also pointed to the importance of human capital formation during Portuguese economic stagnation (1870-1913) and during its “Golden age”, later in the 20th century. Hence, human capital formation may play a crucial role in the divergence of Portuguese living standards from the European reference sample. The development of human capital (i.e. education and skills in the broadest sense) has two possible influences on height trends. Firstly, well educated parents, and mothers in particular, might develop and apply knowledge about healthy behavior. For example, hygienic standards tend to be higher if household members are more educated, and nutrition provided to children might contain more important nutrients (for example, protein and calcium which are contained in milk). The other channel via which human capital impacts on height trends is the income channel, as income partly depends on the skills and abilities and hence on the human capital endowment. Income, as mentioned earlier, determines the quality and quantity of food, shelter and medical care. This second part of the human capital effect will be captured by the real wage variable in some of the regressions below.

7 Especially if parents suffer from lactose intolerance themselves, they might provide cow milk only if they know that children are not lactose tolerant until age 5.
We have compiled a data base for literacy data for Portugal and the other European regions. Eastern Europe is represented with data on Russia and Poland, the south contains Italy and Spain as in our other variables and central Europe contains the UK, the Netherlands, Ireland, Austria, France, Sweden and Germany. Figure 9 shows Portugal as a laggard of the sample after mid-19th century. The literacy data for Portugal begins only in the 1830s. In order to extend our analysis backwards, we use another human capital indicator that captures a more basic form of human capital. Recently, a literature has evolved that uses the share of persons who report their exact age as an indicator for basic numeracy (Mokyr 1983, Baten and Crayen 2009a and 2009b, A’Hearn, Baten and Crayen 2009, de Moor and van Zanden 2008, Clark 2007, Manzel and Baten 2009, Baten, Crayen and Manzel 2008, see also the applications in Cinnirella 2008, O’Grada 2006). A’Hearn, Baten and Crayen (2009) have shown that within societies characterized by a lower level of human capital, the frequency of people stating their age erroneously is higher than in more developed societies. The tendency is to mention a convenient multiple of five instead of the exact age, which becomes evident in the frequency distribution of the age data. The frequency of multiples of five in relation to the frequency of all mentioned numbers is defined as the Whipple Index. The optimum is 100, i.e. an equal distribution of ages throughout the population, the extreme of 500 occurs, if everybody mentions a multiple of five only. The ABCC index employed below is a simple linear transformation of the Whipple index. It represents the percentage share of the population who reported an exact age, according to the estimates (A’Hearn et al. 2009). Those authors have shown that the Whipple- and ABCC Indexes correlate strongly with the literacy rate, a relation which does not vary much across time and which is robust when applied to different types of data sources.

For Portugal from the 1870s, Crayen and Baten (2009a) provide data, which was augmented here with a small sample from inquisition records on individuals who were born
between the 1700s and 1730s (N=108, Table 4).\textsuperscript{8} The latter sample might be slightly upwardly biased in terms of numeracy, as the inquisition persecuted a large number of persons because of exercising Jewish religious activities, and the Jewish have a reputation for good education during this period (Botticini and Eckstein 2006). However, the occupations of the sample included 28% workers and labourers, some pastoral people and a number of artisans, apart from the trading occupations which might be regarded as above-average human capital intensive. Occupations are reported for 64 accused persons. Moreover, we studied Portuguese who had migrated to Brazil.\textsuperscript{9} We benchmarked their ABCC on the 1870s Portuguese national level of non-migrants and only used the change over time.\textsuperscript{10} The sample for European regions 1750 and 1800 is created in a similar fashion as the regions for the height data. For the east, we included Russia, plus an estimate for Hungary; the south is represented by Italy and Spain and central Europe by a sample of Germany, Austria, France, the UK, and Denmark. After 1800, we have a constant group of countries. In the 18\textsuperscript{th} century, we have only Hungary and Italy to represent the east and south of Europe. The increase until 1750 was a real phenomenon, as it took place in a number of countries, as well as the stagnation between 1750 and 1800 (see Table 4 in A’Hearn et al. 2009).\textsuperscript{11}

How does Portugal compare with this sample of European countries (Table 4)? During the 18\textsuperscript{th} century Portugal compares quite well with other European countries. Among the Portuguese birth cohorts of the 1820s, only an estimated 79 percent stated their age exactly, whereas the central European sample already reached 97 percent during this period.\textsuperscript{12} During the mid-19\textsuperscript{th} century, Portuguese basic numeracy developed more rapidly than the European sample and converged somewhat. But during the 1870s and 1880s, Portugal still kept the

\textsuperscript{8} We thank Kerstin Manzel and Rose Triebe for providing this evidence, which was obtained from the register of inquisition records provided by the Portuguese National Archive (Torre do Tombo).
\textsuperscript{9} See Stolz, Baten, Botelho (2010) for details.
\textsuperscript{10} Numeracy selectivity among emigrants and stayers was very small in the 1870s.
\textsuperscript{11} Southern and Eastern Germany had relatively low rates of basic numeracy during this period.
\textsuperscript{12} However, Portugal was clearly ahead of Serbia (55 percent in 1800, in a rural sample, see A’Hearn et al. 2009), and in the same range as Ireland (77%) and the Czech lands (84%) around 1800.
lowest rank. The birth cohort of the 1870s stood at only 92%, 7 percent less than the Central European average, when countries such as Hungary, Croatia or the Czech lands had largely solved their numeracy problem (98-99 percent). Only in the Russian Empire and at the borders of the Ottoman Empire, some regions were lagging more than Portugal. The birth cohort of the 1900s still had a small age heaping problem with 96 percent age numeracy.

In sum, Portugal was probably among the more numerate nations of Europe during the early 18th century, but became a laggard at some point before the early 19th century. Portugal had a clear problem of basic age numeracy still among the 1870s birth cohort, when many of the poorer European countries had developed more rapidly, and divergence in nutritional status began to open up. It might be that the underinvestment in human capital during the late 18th and early 19th centuries contributed to the disappointing height and income development in this and the following period. This leads to a hypothesis of a positive influence of the ABCC-index on heights, which will be tested in the regressions. For the period in which data on literacy is available, we counter-check our numeracy results with literacy as a proxy for human capital.

Urbanization

Other studies have found a negative effect of urbanization on health trends (Komlos and Baten 2004). Disease environment and food supply of perishable goods might be more difficult in an urban environment because of the crowdedness and hygienic problems in 19th century cities. Costa Leite (2005) and Valerio (2001) provide urbanization rates from 1800 to 1980. Compared to other European countries, urbanization was actually a slow process in Portugal. Around 1800, less than 15 percent of Portuguese population lived in towns with more than 10,000 inhabitants, whereas the Mediterranean European average already reached an urbanization rate of 32.9 percent (de Vries, 1984). Reis (2002/03 and 2009) has studied living standards of the Portuguese capital in comparison with rural dwellers. Notwithstanding
the fact, that Lisbon was perceived as a harmful place to live in by contemporaries, Reis found, in fact, that a small positive urban height premium existed during the second half of the 19th century. We confirm this finding with our data. Hence, the urbanization process seems not to have provoked the noted divergence in Portuguese nutritional status vis-à-vis the European average, which is why we do not control for urbanization in our regressions.

Protein and grain supply and relative prices of protein

Cámara (2009) found that a breakdown in high quality protein supply during the 18th century might have influenced the deterioration of nutritional status in Andalucía. Baten (1999 and 2009) and Stegl and Baten (2009) have shown that protein supply and protein proximity can play an important role in nutritional status. In pre-industrial societies, among rural dwellers who were equally poor in purchasing power terms, often people who had more domestic livestock which provided high quality protein, had a better nutritional status than others. Even those who did not own cattle could sometimes buy milk at very low prices. This holds particularly for the time before milk became transportable. Did Portugal also experience a decrease in livestock production? Justino (1988) provides data on protein supply in his thesis on market formation in Portugal during the 19th century. Three livestock censuses were carried out in Portugal, in 1852, 1870 and 1925. Additionally, there was one enumeration of livestock in 1906 (see Table 5). Justino finds that in spite of an absolute growth in livestock during the period considered, livestock per capita decreased slightly until 1906, whereas it increased in many other European countries (such as Germany, see Hoffmann 1965). Cereal and potato production however, kept pace with population growth (Justino 1998: 110). This might be due to tariff barriers and protectionist policies which made grain production more attractive compared to livestock breeding. Declining land per capita values during this period also made animal husbandry more costly, as productivity per area of land was lower than in the case of grain and especially potatoes. Prices in Lisbon reflect this development in the late
19th century. Reis (2002/03) finds that relative prices for protein supply increased in relation to carbon hydrates, which is why, a substitution of meat with cereals might have taken place. This might have reduced nutritional status, in particular of the lower strata of society which would have been more sensitive to relative price alterations.

For the 19th century, we assess whether the relative price of meat had a negative effect on heights (Figure 10). Here, we compiled a series for Barcelona and Madrid, to represent the European south, the UK stands for the central European group and Krakow and Danzig for the European east. Surprisingly, the grain meat ratios do not behave as we would have expected. In comparison to other European regions, in Lisbon, meat seemed relatively cheap, which might have been driven by lower relative demand. In the south less meat was demanded because the first necessity was to fill the stomach and gain calories, not to absorb protein, and therefore Portuguese consumed relatively more bread. Markets for meat were poorly integrated due to high transport costs. The result was that although meat was a "cheap luxury" they still could not afford much of it.

Migration

Selective migration might also have an impact on anthropometric outcomes. Given that migration is often selective in terms of human capital and height, it might be that the tallest leave the country, reducing the height average in the country. Migration plays an important role in Portuguese history. Particularly during the last decade of the nineteenth century and in the beginning of the twentieth century emigration was an option for many Portuguese. Hatton and Williamson (1998) report that decadal emigration rates increased substantially, from 1.9% during the 1860s to a rate of 5.7% in the first decade of the 20th century, and then declined again (Ferenczi 1929). However, Portuguese emigration does not seem to have been very

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13 We thank Bob Allen for his comments on this point. He actually observed the same unexpected differences and they seem not to be caused by measurement error.
14 We also tested the variable cattle per capita, but the results were insignificant, perhaps due to the fact that productivity per head of cattle was different in Europe’s regions.
selective. For example, Baten, Pelger, and Twrdek (2009) assessed the height selectivity of Portuguese migrants to Brazil and found that their height was not much different from stayers. Given the rates of migration (and the large birth and death rates within Portugal), the height bias due to selective migration was not substantial. The average height of 1070 Portuguese males (age 20-54) who had migrated to Latin America and were born between the 1850s and 1880s was 165.1 cm, i.e. very close to the Portuguese average, between 164 and 165 cm. Passenger lists of Portuguese immigrants found in the national Archive of Rio de Janeiro in Brazil also do not show pronounced selectivity in terms of numeracy. Almost throughout the 19th century, numeracy levels of Portuguese migrants are in the same range as numeracy in Portugal itself. This suggests that other forces were at work that drove Portugal’s anthropometric divergence from the European core.

**Disease environment**

Of course, height trends are sensitive to disease environment, as the body only translates nutrients into growth after accounting for all bodily needs. That means that unfavourable disease environments can hinder individuals to reach their full growth potential. Infant mortality rates are often used as a proxy for disease environment during early childhood, partly because age composition does not require adjustments, as in the case of crude death rates. Infant mortality rates for Portugal are unfortunately only available for 1800, the 1860s, 1890s and 1900s, which is not enough for our regressions below. Furthermore, these data show that actually Portuguese infant mortality was on the same level as central Europe, whereas the east and south of Europe performed far worse. Hence, this variable would not help to explain the Portuguese height divergence from the European core (Figure 11).

**Econometric test results**

In order to test our hypotheses we aggregated the European countries into three regions, namely south, central and east Europe. With these three regions and Portugal we estimated an
unbalanced panel with average height as dependent variable and real wages, human capital and relative prices for meat as explanatory variables.¹⁵ Infant mortality cannot be included here. Some of the European-wide shocks will be picked up, however, by the time fixed effects, like the Cholera epidemic during the 1830s. We restrict our analysis to the 1720s to 1910s period, because the 20th century series are characterized by strong trend correlation. Ending in the 1910s we obtain the longest time frame that does not pose unit root problems. The empirical equation we estimate is the following:

\[ \text{Heights} = \beta_1 + \beta_2 \times \text{real wages} + \beta_3 \times \text{human capital} + \beta_4 \times \text{relative prices} + \text{time fixed effects} + \text{regional fixed effects} + \epsilon_i \]

We took the logs of the price ratios and the real wages variables, as distributions would have been otherwise skewed. We lagged our human capital indicators by two decades to make sure we are measuring numeracy and literacy of the parents’ generation. This also helps to avoid endogeneity problems by removing contemporaneous correlation. All estimations are weighted by average population size of the respective regions, the population figures refer to the same countries as the other variables (Maddison 2001). We expect the relative price of meat to show a negative sign, as it increases as proteins become more expensive. Both real wages and human capital should have a positive effect on heights. In a first step we regress only the human capital proxies on heights controlling for time effects with birth decade dummy variables (Table 6). Numeracy (ABCC indexes) has a large impact on our dependent variable and literacy performs similarly. What happens, if we include both real wage and human capital into the equation? Both coefficients are positive and strongly significant. The magnitude of both human capital proxies decreases, which shows that the human capital effect on heights works partially via income. Our \(R^2\) is quite reasonable for all specifications and it increases when real wages are included in the model. If we control for regional and

¹⁵ We did not include urbanization and migration variables, for already mentioned reasons.
time fixed effects, the results are robust (Column 7). In a next step, we examined the effect of
relative prices of meat on height. These show the right sign in all specifications, but are not
only in one specification statistically significant.  

Can we speak of economic significance of our coefficients? A frequently applied
technique to judge the economic significance is to multiply the coefficients with standard
deviations of the explanatory variables. This allows, for example, comparing ‘average’ and
‘high’ values of the explanatory variable. For example, a standard deviation of numeracy is
0.108, multiplied with the numeracy coefficient in model (1) we receive 1.7 centimetres.
Explained differently, if we compare an observation with average numeracy with an
observation which represents the average numeracy plus one additional standard deviation of
numeracy, we would predict 1.7 cm higher anthropometric welfare measures in the ‘high’

Moreover, 1.7 cm is regarded in most of the anthropometric literature as an economically
significant value (Baten 2009). Doing the same exercise with literacy (model 2), we even
arrive at a difference of 2.4 cm, and the real wages which are one standard deviation higher
are estimated to result in 1.6 cm additional height. The importance of literacy and numeracy
for height trends is consistent with the finding of recent research that finds health outcomes to
be strongly associated with illiteracy in Brazil and the US (Messias 2003).

Conclusion

We have studied the Portuguese biological standard of living over the past three centuries.
The Portuguese were the shortest in Europe, even in the year 2000, despite three decades of
favorable economic development. We explored the question: have they been always the
shortest in Europe? And if not, when and why did this happen? As it turns out, the Portuguese
have not always been the striking outlier in terms of heights compared to other European

16 Note that in specifications with regional fixed effects we control for time fixed effects with half-century
dummies, due to the small number of cases.
regions. The early 18\textsuperscript{th} century was characterized by height levels relatively similar to the European average. Divergence from other European countries took place in the 1840s and became more accentuated during the 1870s. From 1890 on, Portuguese were the shortest in Europe. We further scrutinized the determinants of the retarded height development, by focusing on the period until 1910, which was when the gap had opened up. The modest real wage evolution, given Portugal’s late industrialization and economic growth performance in comparison to the European core, was one of the important determinants. Relative prices seem to have played a minor role. Moreover, we find the retarded human capital formation to be of importance. Those findings relate actually to all of Europe, because we have studied here the Portuguese welfare development and its determinants in comparison with Eastern, Central and Southern Europe.

References


Carreras, A., Tafunell, X. (2004), Historia económica de la España Contemporánea, Crítica, Barcelona


Schaumburg-Lippe-Bückeburg, Friedrich Wilhelm Ernst Graf zu (1762): Regulamento para o Exercício e Disciplina dos Regimentos de Infantaria dos Exércitos de Sua Magestade Fidelíssima feito por ordem do mesmo senhor por sua Alteza o conde Reinante de Schaumbourg, marechal Lippe (Lisboa, Regia Oficina Tipográfica, 1794).

Mapas Estatísticas dos Baptismos, Casamentos e Óbitos que houve no Reino durante o ano 1860. Boletim do Ministério dos Negócios Eclesiásticos e da Justiça, 1863, Lisbon.


### Tables and Figures

Table 1: Height data sources

<table>
<thead>
<tr>
<th>Source</th>
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<tr>
<td>Arquivo Distrital do Porto</td>
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<tr>
<td>Arquivo Geral do Exército</td>
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<tr>
<td>Arquivo Histórico Militar</td>
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<tr>
<td>Arquivo Distrital de Évora</td>
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<td>Arquivo Distrital de Faro</td>
<td>174</td>
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<tr>
<td>Reis (2002/03, 2009)</td>
<td>37,698</td>
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<td>Total</td>
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*Source: authors’ calculations.*
Table 2: Number of cases by recruitment decade and by birth decade

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<td>205</td>
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<td>1790</td>
<td>784</td>
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<td>1800</td>
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<td>1740</td>
<td>594</td>
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<td>1750</td>
<td>216</td>
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<td>583</td>
<td>1760</td>
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<td>1840</td>
<td>490</td>
<td>1770</td>
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<td>1850</td>
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<td>1860</td>
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<td>1870</td>
<td>8,871</td>
<td>1800</td>
<td>382</td>
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<td>1880</td>
<td>11,159</td>
<td>1810</td>
<td>474</td>
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<td>2,636</td>
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<td>4374</td>
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<td>1910</td>
<td>3,059</td>
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<td>1920</td>
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Table 3: Estimation of the height trend 1720s-1910s

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<th>Recruitment regime 1857</th>
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<td>bdec1720</td>
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<td>bdec1730</td>
<td>1.286**</td>
<td>age18 -1.198***</td>
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<tr>
<td>bdec1740</td>
<td>1.360***</td>
<td>age19 -1.097***</td>
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<tr>
<td>bdec1750</td>
<td>1.284**</td>
<td>age20 -0.901***</td>
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<td>bdec1760</td>
<td>1.474***</td>
<td>age21 -0.663***</td>
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<td>bdec1770</td>
<td>1.185**</td>
<td>age22 -0.396**</td>
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<td>age18</td>
<td>-0.743***</td>
<td>bdec1820 1.191</td>
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<td>bdec1830 -1.213***</td>
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<td>age20</td>
<td>-0.158</td>
<td>bdec1840 -1.481***</td>
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<td>age21</td>
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<td>bdec1850 -0.850***</td>
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<td>age22</td>
<td>-0.002</td>
<td>bdec1860 -0.953***</td>
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<tr>
<td>Grenadiers</td>
<td>2.780***</td>
<td>bdec1870 -0.337**</td>
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<tr>
<td>Tall region</td>
<td>-0.436</td>
<td>bdec1880 -0.927***</td>
</tr>
<tr>
<td>Constant</td>
<td>61.919***</td>
<td>bdec1890 -0.810***</td>
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<td>Tall region 0.519***</td>
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<tr>
<td>N</td>
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<td>N 43216</td>
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<tr>
<td>Wald chi(13)</td>
<td>614.95</td>
<td>Wald chi(13) 88.01</td>
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<tr>
<td></td>
<td></td>
<td>R² 0.0043</td>
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*/**/***significant on 1%/5%/10%. Constant for 1763 refers to a infantry recruit born in the 1780s aged 23-50 born in one of the non-extremely regions (Beja, Faro and Évora). Constant for 1820 the same, but born in the 1830s. Constant for 1857 the same, but born in the 1910s.
Table 4: Numeracy (ABCC indexes) for Portugal and European regions, 1720s-1910s

<table>
<thead>
<tr>
<th>Birth decade</th>
<th>Center</th>
<th>East</th>
<th>Portugal</th>
<th>South</th>
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<td>1720</td>
<td>85</td>
<td>59</td>
<td>76</td>
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<tr>
<td>1750</td>
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<td>1800</td>
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<td>1910</td>
<td>100</td>
<td>99</td>
<td>97</td>
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</table>

Sources: Crayen and Baten (2009a), A’Hearn, Baten and Crayen (2009), own calculations. We thank Valeria Prayon for providing important evidence.

Table 5: Livestock production in Portugal 1852-1925

<table>
<thead>
<tr>
<th></th>
<th>1852</th>
<th>1870</th>
<th>1906</th>
<th>1925</th>
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<tbody>
<tr>
<td>Total heads of livestock</td>
<td>5074717</td>
<td>5206920</td>
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<tr>
<td>Total heads standardized</td>
<td>1128428</td>
<td>1158794</td>
<td>1451672</td>
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<tr>
<td>Population estimated</td>
<td>3509134</td>
<td>4084446</td>
<td>5330751</td>
<td>5992116</td>
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<tr>
<td>Standardized livestock/population</td>
<td>0.32</td>
<td>0.28</td>
<td>0.27</td>
<td>0.29</td>
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</table>

Source: Justino (1988: 119) – in relation to cattle, Justino defined that a standardized head of livestock (cattle=1) was 15 sheep or goats or 6 pigs.
Table 6: Unbalanced panel of European regions 1720-1910 - dependent variable: mean height

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<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
<th>(6)</th>
<th>(7)</th>
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<tr>
<td>Numeracy (lag)</td>
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<td>10.76***</td>
<td>11.16***</td>
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<tr>
<td></td>
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<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
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<td></td>
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</tr>
<tr>
<td>Literacy (lag)</td>
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<td>5.71***</td>
<td>5.65***</td>
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<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.00)</td>
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</tr>
<tr>
<td>Real wages (log)</td>
<td>3.83***</td>
<td>2.61***</td>
<td>3.97***</td>
<td>2.59***</td>
<td>3.83***</td>
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<tr>
<td>Relative price of protein</td>
<td>1.56**</td>
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<td>Time fixed effects</td>
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<td>Included</td>
<td>Included</td>
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<tr>
<td>Region fixed effects</td>
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<td>Included</td>
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<td>Constant</td>
<td>154.75***</td>
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<td>161.84***</td>
<td>161.87***</td>
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<td>34</td>
<td>63</td>
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<tr>
<td>R-sq. adj.</td>
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<td>0.91</td>
<td>0.84</td>
<td>0.91</td>
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</tr>
</tbody>
</table>

Robust p-values in parentheses. *** p<0.01, ** p<0.05, * p<0.1 Estimations weighted by population share of regions. Regression (7) includes half-century dummies to control for time fixed effects. Numeracy and literacy values are expressed between 0 and 1. Numeracy (ABCC) is linearly interpolated where values were missing.

For expository purposes, numeracy and literacy was expressed in fractions between 0 and 1 in the regressions.

Residuals of all models are stationary (Fisher-Test Chi-square-value smaller than 0.001, H0 of a unit root can be rejected.). Means and standard deviations for the 63 cases in models 5 and 7, and the 34 cases in model 6 are:

- height (165.33, 1.976),
- numeracy (0.857, 0.108),
- Log real wage/welfare ratio (-0.159, 0.413)
- Log relative price of meat (1.503, 0.400).
Figure 1: Share of skilled occupations in percent
Figure 2: Histogram of polegadas in 1763-1774

Figure 3: Histogram of polegadas in 1776-1802

Figure 4: Histogram of polegadas, recruitment period 1820s
Figure 5: Height development of Portugal 1720-1910, alternative measures for pre-1770 period

Figure 6: Portuguese versus European heights 1720-1980.

Figure 7: Lisbon Real Wages ("Welfare ratios") in Portugal 1720-1910. Source (own estimations, PWR Project)

Figure 8: Welfare ratios (=real wages) in European cities (log scale)

Figure 9: Literacy in Europe late 18th to early 20th century, by birth decades


Figure 10: Relative Prices of Meat and Grain for four European Cities.

Figure 11: Infant Mortality Rates

European south (Italy, Spain), east (Russia, Poland), center (Austria, France, UK, Ireland, Sweden). Source Baten and Blum (2010), for Portugal: Rodrigues (2008) for 1860s data is taken from Boletim do Minitério dos Negócios Eclesiásticos e da Justiça, no 7, pp. 124-129, Costa Leite (2005) for 1900, 1910 is taken from census data.